PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 9 (7): 696-702, 2010
ISSN 1680-5194

The Effect of Green and Oolong Tea Extracts Supplementation on Body Composition in Wrestlers

Joanna Bajerska, Jan Jeszka, Aleksandra Kostrzewa Tarnowska and Magdalena Czlapka-Matyasik
Department of Human Nutrition and Hygiene, Faculty of Food Sciences and Nutrition,
The Poznan University of Life Sciences, Wojska Polskiego 31, 60-624 Poznan, Poland

Abstract: We examined the effect of both Green and Oolong Tea Extracts (GTE, OTE) with different Epigallocatechin Gallate (EGCG) and Caffeine (C) levels on body weight and composition in Wrestlers (W). A randomized, controlled trial was conducted. 30 male wrestlers were randomly assigned to 1 of 3 treatments group: GTE, OTE, or Placebo (P). Athletes daily ingested 509.9 mg EGCG, 36.9 mg C and 172.0 mg EGCG, 138.2 mg C from GTE and OTE, respectively. After 6 weeks supplementation period the athletes lost mean 0.6±0.1 kg (0.8%); $p<0.05$ and 1.4±0.3 kg (1.6%); $p<0.01$ their body weight in GTE and OTE group respectively. Body weight loss in both GTE and OTE group was primarily due to absolute fat loss, but only in the OTE group this result was significant (GTE: 1.3±0.6 kg, 8.6%; OTE: 1.9±0.3 kg, 8.0%; $p<0.05$). No significant differences in mean energy balance values were observed after supplementation period in groups ingested GTE, OTE or P. We conclude that for wrestlers during the training period, for healthy body weight reduction, accompanied with fat mass loss, it seems reasonable to recommend supplementation of 2.4 g/day of OTE where EGCG content is similar to C.

Key words: Body weight, fat mass, green tea extract, oolong tea extract, wrestlers

INTRODUCTION

It has been established that many athletes from weight-sensitive disciplines (e.g. wrestlers, boxers, judokas and rowers) strive for a rapid weight loss just before weight-in time to qualify for a lower weight division (Oppliger *et al*., 2003; Rankin, 2002). The major motivation for those athletes to lose weight is the hope of achieving greater success by competing in a lower weight class (Oppliger *et al*., 2003; Fogelholm *et al*., 1993). Traditionally many athletes from those disciplines have used aggressive methods such as food restriction, dehydration, vomiting, diuretics and exercise in thermal environments to accomplish weight loss (Rankin, 2002; Wagner, 1996; Horswill *et al*., 1990). Athletes who use drastic food or fluid restriction to lose weight may experience negative consequences, including loss of lean tissue accompanied by a decrease in metabolic rate and hormonal disturbances (Rankin, 2002; Horswill *et al*., 1990). Maffulli (1992); Dale and Landers (1999) indicated that rapid weight loss was strongly associated with reduced physical performance of athletes, e.g. in wrestlers was connected with reduced strength endurance and anaerobic capacity or muscle weakness, thermoregulatory problems, renal system dysfunctions and blood pressure abnormalities. The study conducted by Fogelholm *et al*. (1993) on wrestlers also confirmed that rapid weight loss was associated with an increased risk of stress fractures and impaired physical performance. Moreover Tsai *et al*. (2009) demonstrated that prolonged intensive training and rapid weight reduction significantly increased of upper respiratory tract infections incidence-URTI (by suppressed mucosal immunity) after competition in elite male Taiwanese Taekwondo.

In this context, new dietary supplements have been searched for, which could enable athletes to promote the body fat loss while maintaining the content of fat-free mass. During the last decade, numerous studies have focused on the identification of food supplements of plant origin, which would support a reduction of body weight. Based on the research data such benefits seem to be found in a non-fermented green tea and/or partially-fermented oolong tea (Cabrera *et al*., 2006; McKay and Blumberg, 2002; Sato and Miyata, 2000; Yang and Landau, 2000). Green and oolong tea, widely consumed by the Japanese and Chinese population as one of the most popular and traditional non-alcoholic beverages, may retain a considerable amount of the original bioactive compounds, such as caffeine and catechines, in particular Epicatechin (EC), Epicatechin Gallate (ECG), Epigallocatechin (EGC) and Epigallocatechin Gallate (EGCG) (Graham, 1992; Zheng *et al*., 2004). Moreover, obese people are seldom found in populations of long term tea drinking individuals group (Wu *et al*., 2003). Chen *et al*. (1998) observed that Chinese women who drank four cups of 2 g Oolong tea infusion per day lost over a kilogram of body weight during a six-week period. In turn, several reports have

Corresponding Author: Joanna Bajerska, Department of Human Nutrition and Hygiene, Faculty of Food Sciences and Nutrition, The Poznan University of Life Sciences, Wojska Polskiego 31, 60-624 Poznan, Poland

shown that the administration of polyphenols resulted in a significant reduction in body weight gain and body fat accumulation induced by high-fat diet in both animal and human subjects (Hsu *et al.*, 2006, Han *et al.*, 1999; Bose *et al.*, 2008; Ito *et al.*, 2008; Yang *et al.*, 2001). For example, the results of the study conducted by Hsu *et al.* (2006) indicated that polyphenol-enriched oolong tea could increase lipid excretion into feces when subjects consumed a high-fat diet. Other research showed that oolong tea prevented body weight increase and parametrial adipose tissue in mice fed with a diet containing 40% beef tallow for 10 weeks (Han *et al.*, 1999). Bose *et al.* (2008) indicated that long-term EGCG treatment attenuated the development of obesity in mice fed a high-fat diet (60% energy from fat) as shown in the supplementation with dietary EGCG (3.2 g/kg diet) for 16 weeks.Only Hsu *et al.* (2008) showed in a double-blind, placebo-controlled one-year clinical trial conducted at a Taipei Hospital no statistical differences in percentage reduction in body weight, BMI and waist circumflex between treated GTE (491 mg catechins containing 302 mg EGCG) vs. placebo. It was showed that dietary GTE supplementation, combined with regular exercise, stimulates fat reduction and attenuates obesity induced by a high-fat diet in mice (Shimotoyodome *et al.*, 2005). In spite of great interest, there is scant information concerning the effect of tea extract supplementation on body weight and body fat mass in non-obese subjects obligated to control body fat content as, for example, professional athletes from "weight sensitive" disciplines. Therefore we examined the effect of GTE and OTE with different EGCG and C levels on body weight and its composition in wrestlers.

MATERIALS AND METHODS

Subjects: A total of 35 Greco-Roman wrestlers aged between 18-24 years were recruited for the present study from the "Sobiesky Poznan" wrestling team. All of the athletes competed at the national level. They were subjected to medical examination and were screened for supplement use and the length of their training period. This process resulted in the selection of 30 wrestlers who were in good health, not using medication/supplements decreasing their body mass. The experiment was performed during the preseason conditioning program. Before the supplementation period athletes were matched for age, body weight, height and percentage fat mass. The enrolled subjects were randomly allocated to one of the three treatments: a total of 10 wrestlers were supplemented with GTE, 10 with OTE and 10 athletes received P for 6 weeks. A random numbers were generated by the computer for each subject. All of the subjects gave their written information consent. The study was approved by the head of wrestling coaches and the Poznan Medical Ethics Committee.

Experimental design: The subjects were asked to take two capsules three times per day for 6 weeks. Each capsule (400 mg) containing 60% of GTE or 40% OTE or 100% cellulose as placebo. The capsules were taken 30 min after meals (breakfast, lunch and dinner). The GTE and OTE and P capsules were indistinguishable in color, size and appearance. During the supplementation period athletes had a regular diet containing 55% calories from carbohydrates, 25% form lipids and 15% from proteins. Athletes received guidelines from a dietician, listing allowed and prohibited foods with recommended serving sizes and possible combinations. Athletes reported to the laboratory on 4 occasions-baseline (week 0), 2, 4 and 6 week, when they were weighed only in essential clothing. Body composition was determined using bioelectric impedance during each visit. Measurements at baseline and up to week 6 were taken at approximately the same time and day of the week and by the same researcher.

Preparation of sample and treatment: The GTE was obtained by water extraction from dry tea leaves of unfermented *Camellia sinensis*, according to the standard procedures with certificate of analysis given and commercially prepared in capsular form. The manufacturer was Olimp Green Tea®, Sportatut, Debica, Poland. The OTE was obtained by water extraction from dry leaves of semifermented *Camellia sinensis* (Oolong Formosa tea, purchased from Akso® Krakow Company from Poland), according to the standard procedures with certificate of analysis given and commercially prepared in capsular form by the Synteza®, Poznan, Poland. The placebo given to the control group comprised cellulose. GTE in two capsules-800 mg contained 16.4 mg of C and 226.6 mg of EGCG, in this supplement the level of C was lower than EGCG. OTE in two capsules (800 mg) contained 46.0 mg of C and 57.2 mg of EGCG-in this supplement C and EGCG contents were similar. Placebo in two capsules (800 mg) contained cellulose. Consequently, the ingestion of capsules containing the green or oolong tea extract provides daily a total 49.2 mg and 679.8 mg; 138.0 mg and 171.6 mg of C and EGCG respectively. Extraction and HPLC analysis were performed according to the standard procedures (Gramza and Regula, 2007; Zuo *et al.*, 2002). Greater than 15% of the products were randomly tested and their components were differed by < 5%. Results of HPLC analysis of each treatment are presented in Table 1.

Measurements: Height of the subjects was measured by using anthropometer (model WPT 200.0 by Rad Wag, Poland), at the time entry into the study. Body weight was measured with an electronic scale (model WPT 200.0 by Rad Wag, Poland and weighing accuracy of 0.1 kg) morning, before breakfast and after defecated, in

Table 1: Components of polyphenols and caffeine in GTE and OTE (400 mg each capsule)

	mg (% weight)		
Components (mg)	Placebo (P)	Green Tea Extracts (GTE)	Oolong Tea Extracts (OTE)
EGCG	0	113.3 (28.3)	28.6 (7.2)
Caffeine	0	8.2 (2.1)	23.0 (5.8)
Other polyphenols substances*	0	118.4 (29.6)	148.0 (37.0)
Cellulose	400.0 (100.0)	160.0 (40.0)	200.0 (50.0)

*Rest of green and oolong tea extract components comprised: catechines fraction, phenolic acids, polymerized polyphenols etc

subjects dressed in their underwear only. Body composition in terms of the adipose tissue (FM) and lean body mass (FFM) was determined immediately after body weight measurements, by the bioelectric impedance technique using a BIA 101S, (AKERN–RJL) bioanalyser, according to recommendations by Lukaski (1987). The Total Energy Expenditure (TEE) was evaluated by the HR-Flex method (Jeszka *et al*., 2001). The TEE in athletes was measured twice in each weeks of treatment period. The evaluation of energy, macro and micro nutrients intake was carried out by 24-h dietary recalled with the use of "Album of Photographs of Food Products and Dishes". The energy value of individually Daily Food Rations (DFR) was estimated with the use of "Dietetyk" software. TEE and net energy balance were approximated and monitored throughout the training.

Statistical analysis: All data were analyzed using StatSoft Software (Version 8.0). Differences in changes of body weight, percentage of fat mass and energy balance over time and between the treatments (GTE, OTE and P) were determined using two-factors ANOVA with repeated measures. If a significant F ratio was obtained, Tukey's HSD was used to locate differences between means. The t-test was used to test differences in means (between baseline in each of treatment group) between baseline and end of treatment in GTE; OTE and P. Statistical significance was set at 0.05.

RESULTS

The characteristics of the subjects before the intervention are presented in Table 2. The variables used to match subjects were not significantly different and thus balanced treatment groups were achieved. By week 6, treatment resulted in a significant total weight loss of 0.6±0.1 kg (0.8%) in the GTE group ($p<0.05$) and of 1.4±0.3 kg (1.6%) in the OTE group ($p<0.01$). In the P group after a 6 week supplementation period body weight decreased non-significantly (P: 0.1±0.2 kg (0.1%, Table 3). There was a significant difference ($p<0.05$) in body weight changes only between the OTE and P groups at weeks 4 and 6 (Fig. 1).

The total body weight reduction observed during the six week GTE or OTE treatment was accompanied by a significant decrease in absolute FM, but only in the OTE group (FM: -1.9±0.3 kg (8.0%); $p<0.05$, Table 3). There was a significant difference ($p<0.05$) in the %FM

Table 2: Baseline characteristics of 3 treatment groups[1]

Parameters	P Group (n = 10)	GTE treatment Group (n = 10)	OTE treatment Group (n = 10)
Age (years)	21.0±0.3	21.0±0.5	20.5±0.2
Height (cm)	176.0±3.0	179.0±3.0	179.0±1.5
Body weight (kg)	83.1±4.4	79.6±4.7	86.8±2.5
Body fat (%)	18.4±2.4	17.5±1.6	21.5±1.9

[1]Mean±SEM; subjects stratified at baseline for age, height, body weight, body fat %. Subjects matched for characteristic; no differences between groups were statistically significant by one factor ANOVA ($p<0.05$)

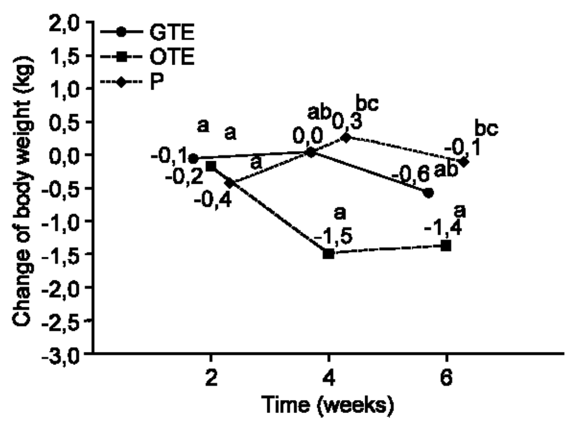

Fig. 1: The changes of body weight of subjects in green tea extracts group (●; n = 10), Oolong tea extracts group (■; n = 10) and Placebo group (◆; n = 10) after 2, 4 and 6 weeks. Different letters indicate significantly different ($p<0.05$) between groups (repeated-measures ANOVA)

changes between the OTE and P groups at weeks 2, 4 and 6 and between GTE and P, but only at week 6 (Fig. 2).

Neither group experienced a significant change in FFM in the treatment period (Table 3), but in both supplemented groups (GTE and OTE) the FFM increased (GTE: 0.7±0.6 kg (1.1%); OTE: 0.5±0.7 kg (0.7%), while in the P group this body component insignificant decreased (P: -0.4±0.2 kg (0.6%).

No significant differences in mean energy balance values were observed after supplementation period in group of athletes ingested GTE, OTE or P. However in groups of athletes ingested both GTE and OTE were

Table 3: The effect of 6 week supplementation with green tea extracts, oolong tea extracts and matching placebo on body weight and body composition[1]

	Placebo (n = 10)			GTE (n = 10)			OTE (n = 10)		
Parameters	Week 0	Week 6	P vs. Baseline	Week 0	Week 6	P vs. Baseline	Week 0	Week 6	P vs. Baseline
Body weight (kg)	83.1±4.4	83.0±4.1	-0.1±0.2 (0.1±0.3%)	79.6±4.7	79.0±4.8*	-0.6±0.1 (0.8±0.2%)	86.8±2.7	85.4±2.5**	-1.4±0.3 (1.6±0.3%)
FFM (kg)	67.2±2.8	66.8±2.8	-0.4±0.2 (0.6±0.3%)	65.3±3.2	66.0±3.4	0.7±0.6 (1.1±0.9%)	67.8±1.4	68.3±1.5	0.5±0.7 (0.7±1.1%)
FM (kg)	15.9±2.8	16.2±2.7	0.3±0.2 (3.0±1.9%)	14.3±2.1	13.0±1.9	-1.3±0.6 (8.6±5.0%)	19.0±2.2	17.1±1.7	-1.9±0.3* (8.0±2.5%)

[1]Mean±SE, *Mean value was significantly different to that at baseline (p<0.05) (t-student test), **Mean value was significantly different to that at baseline (p<0.01, t-student test), FFM = Fat Free Mass, FM = body fat

Table 4: Energy balance value of green tea extract, oolong tea extract and placebo group at baseline and after treatment[1]

	GTE (n = 10)		OTE (n = 10)		P (n = 10)	
Parameters	Week 0	Week 6	Week 0	Week 6	Week 0	Week 6
Energy balance [MJ/day^{-1}]	-0.16±1.9	-0.98±1.6	0.74±2.4	-1.08±1.9	0.50±1.9	0.50±2.6

[1]Mean±SE

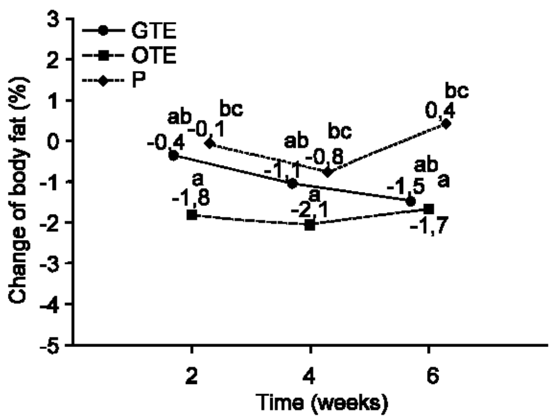

Fig. 2: The changes of body fat % of subjects in Green tea extracts group (●; n = 10), Oolong tea extracts group (■; n = 10) and Placebo group (◆; n = 10) after 2, 4 and 6 week. Different letters indicate significantly different (p<0.05) between groups (repeated-measures ANOVA)

observed tendency to decrease of negative energy balance (Table 4).

DISCUSSION

The present experiment showed that a six week supplementation of GTE and OTE, in which content of EGCG and caffeine was different resulted in a significant reduction of wrestlers body weight: 0.6±0.1 kg (p<0.05) in the GTE and 1.4±0.3 kg (p<0.01) in OTE group. Weight loss in both GTE and OTE group of athletes was primarily due to the absolute fat loss, but only in the OTE supplemented group this result was significant (FM: 1.9±0.3 kg; p<0.05). Numerous studies confirm a positive effect of GTE and OTE treatment on body weight reduction but only in obese people or animals (Chantre and Lairon, 2002; Chan *et al*., 2006; Nagao *et al*., 2005). For example, research conducted in France showed that a three month consumption of GTE at 270 mg of EGCG effectively reduced body weight by 4.6% in obese men and women (Chantre and Lairon, 2002). Nagao *et al*. (2005) in their experiment with overweight persons showed that ingestion of about 690 mg catechins, including 136 mg EGCG and 75 mg caffeine stimulated a significant loss in body weight (2.4 kg) and fat mass. Chan *et al*. (2006) reported that body weight of obese volunteers was reduced by 2.4% after a three-month green tea treatment, although the difference was not statistically significant. Our results were confirmed only in animal studies, where non-obese mice were fed a normal diet, in which a combination of catechines and caffeine was reported to induce a strong suppression of body fat accumulation. This effect was correlated with catechines content in the diet. A higher catechines (0.5%) level was connected with significantly lower body weight gain in rodents (in comparison with the control, Ito *et al*., 2008). Simultaneously, the authors of this study explained that GTE usually contains a smaller amount of caffeine, thus their results are more attributable to the effect of the catechins and not caffeine (Ito *et al*., 2008). Murase *et al*. (2002) using an obese mice model demonstrated that tea catechins at identical dosages as those applied by Ito *et al*. (2008, from 0.1-0.5% catechins) caused a meaningful increment in lipid catabolism in the liver. However, in their study Zheng *et al*. (2004) indicated that catechins and caffeine were synergistic in anti-obesity activities. The findings described by Ito *et al*. (2008) and Murase *et al*. (2002) confirm that catechins (much more than caffeine) at clinically appropriate doses, affect lipid metabolism in non-obese and obese subjects. However, in our results a higher body weight reduction, accompanied with fat mass reduction, was observed in subjects treated with oolong tea powder, where EGCG level was similar to C. Based on biochemical and pharmacological studies, the mechanisms of action of both types of teas (non-fermented and semi-fermented) in preventing obesity may be obtain through stimulating hepatic lipid metabolism, inhibiting gastric and pancreatic lipases (Hsu *et al.*, 2006; Han *et al.*, 1999; Bose *et al.*, 2008; Ito *et al.*, 2008; Yang *et al.*, 2001), stimulating thermogenesis (Dulloo *et al.*, 1999; Dulloo *et al.*, 2000; Komatsu *et al.*, 2003), modulating appetite (Kao *et al.*, 2000) synergism with caffeine and theanine and finally suppressing Fatty Acid Synthase (FAS) (Lin and Lin-Shiau, 2006; Yeh *et al.*, 2003). Lin and Lin-Shiau (2006) studied the mechanisms of hypolipidemic and antiobesity effects of tea and tea polyphenols found that the molecular mechanisms of fatty acid synthase gene suppression by tea polyphenols (EGCG and theaflavins) may incite downregulation of the EGFR/PI3K/Akt/Sp-1 signal transduction pathways. Yeh *et al.* (2003) studied the suppression of fatty acid synthase in MCF-7 breast cancer cells by tea and tea polyphenols found a possible mechanism for their hypolipidemic effects and suggested that tea polyphenols may induce hypolipidemic and antiproliferative effects by suppressing fatty acid synthase. Therefore, antiobesity effect of tea polyphenols could be also observed in the normal (non-obese) people. Described by Lin and Lin-Shiau (2006); Yeh *et al.* (2003) mechanism of action of tea polyphenols can by use to explain reductions in fat mass among the athletes treated of OTE, because contents of theaflavins formed from polymerization of catechins at the semi fermentation stage during the manufacture of oolong is high and amount to ~2 g/100 g of the dried water extract of oolong tea (Subramanian *et al.*, 1999). More research is needed to determine whether oolong tea consumption has an unequivocal hypolipidemic effects benefit and especially which components in tea may be responsible for this effect.

The first thermogenic effect of green tea was attributed to its caffeine content (Astrup *et al.*, 1990; Borchardt and Huber, 1975). However, Dulloo *et al.* (2000) observed that green tea could stimulate thermogenesis to a much greater extent than that which can be attributed to the caffeine content alone. In another study the same researchers found that GTE ingestion increased 24 h energy expenditure by 4% (328 kJ) in 10 health men, reflecting green tea stimulatory effect on thermogenesis (Dulloo *et al.*, 1999). Dulloo *et al.* (1999) explained that catechins in green tea and oolong tea may stimulate thermogenesis and fat oxidation through an inhibition of catechol *O*-methyl-transferase, an enzyme that degrades noradrenaline. In our research, we only observed tendency to negative energy imbalance, supported by increase daily energy expenditure between athletes supplemented both green and oolong tea extract. Komatsu *et al.* (2003) stated that consumption of oolong and green tea beverages increased TEE in healthy non obese Japanese females, by 10 and 4% respectively. Also Auvichayapat *et al.* (2008) indicated that green tea capsules in dosage of 100 mg/day EGCG can increase energy expenditure and fat oxidation in Obese Thai subjects in 12 weeks period. In turn, Hsu *et al.* (2006) indicated that polyphenol-enriched oolong tea beverages (27.2 mg EGCG and 134 mg C in 750 ml of beverages) consumed at three meals could increase lipid excretion into feces when subjects took a high-lipid diet (polyphenol-enriched oolong tea beverages: 19.3+/-12.9 g/3 day vs. placebo: 9.4+/-7.3 g/3 day). Wrisez and Lambert (2001) reported also that other polyphenolic compounds, such as tannins and tannic acids, exerted an influence on lipid metabolism in rats. Kao *et al.* (2000) found that rats in a 7-day experiment of daily intraperitoneal injections of EGCG consumed up to 60 percent less food in comparison to the control.

Conclusion: Two important findings may be presented regarding tea extract supplementation. Firstly, supplementation of oolong tea (EGCG content similar to C) caused a statistically significant decrease in fat mass of non-obese subjects in comparison to than following the administration of green tea (C content higher than EGCG). Secondly, the C to EGCG ratio should be in balance to both body weight and fat loss. This study showed also that for athletes from weight-sensitive disciplines, during the training period, for the purpose of healthy body weight reduction, accompanied by FM loss and FFM maintenance, it seems reasonable to recommend the OTE supplementation of 2.4 g/day.

ACKNOWLEDGMENTS

This study was financially supported by the State Committee for Scientific Research (research project n°. 2 P06T 036 26).

REFERENCES

Astrup, A., S. Toubro and S. Cannon, 1990. Caffeine: A double-blind, placebo-controlled study of its thermogenic, metabolic and cardiovascular effects in healthy volunteers. Am. J. Clin. Nutr., 51: 759-767.

Auvichayapat, P., M. Prapochanung and O. Tunkamnerdthai, 2008. Effectiveness of green tea on weight reduction in obese Thais: A randomized, controlled trial. Physiol. Behav., 93: 486-491.

Borchardt, R.T. and J.A. Huber, 1975. Catechol *O*-methyltransferase. 5. Structure-activity relationships for inhibition by flavonoids. J. Med. Chem., 18: 120-122.

Bose, M., J.D. Lambert and J. Ju, 2008. The major green tea polyphenol, (-)-epigallocatechin-3-gallate, inhibits obesity, metabolic syndrome and fatty liver disease in high-fat-fed mice. J. Nutr., 138: 1677-1683.

Cabrera, C., R. Artacho and R. Giménez, 2006. Beneficial effects of green tea--a review. J. Am. Coll. Nutr., 25: 79-99.

Chan, C.C., M.W. Koo and E.H. Ng, 2006. Effects of Chinese green tea on weight and hormonal and biochemical profiles in obese patients with polycystic ovary syndrome--a randomized placebo-controlled trial. J. Soc. Gynecol. Investig., 13: 63-68.

Chantre, P. and D. Lairon, 2002. Recent findings of green tea extract AR25 (Exolise) and its activity for the treatment of obesity. Phytomedicine, 9: 3-8.

Chen, W.Y., Z.B. Yang and K.K. Hosoda, 1998. Clinical efficacy of oolong tea in simple obesity. Japan. Soc. Clin. Nutr., 20: 83-90.

Dale, K.S. and D.M. Landers, 1999. Weight control in wrestling: eating disorders or disordered eating? Med. Sci. Sports Exerc., 31: 1382-1389.

Dulloo, A.G., J. Seydoux and L. Girardier, 2000. Green tea and thermogenesis: Interactions between catechin-polyphenols, caffeine and sympathetic activity. Int. J. Obes. Relat. Metab. Disord., 24: 252-258.

Dulloo, A.G., C. Duret and D. Rohrer, 1999. Efficacy of a green tea extract rich in catechin polyphenols and caffeine in increasing 24-h energy expenditure and fat oxidation in humans. Am. J. Clin. Nutr., 70: 1040-1045.

Fogelholm, G.M., R. Koskinen and J. Laakso, 1993. Gradual and rapid weight loss: effects on nutrition and performance in male athletes. Med. Sci. Sports Exerc., 25: 371-377.

Graham, H.N., 1992. Green tea composition, consumption and polyphenol chemistry. Prev. Med., 21: 334-350.

Gramza, A. and J. Regula, 2007. Use of tea extracts (*Camelia sinensis*) as polyphenols sources in human diet. Asia Pac. J. Clin. Nutr., 16: 43-46.

Han, L.K., T. Takaku and J. Li, 1999. Anti-obesity action of oolong tea. Int. J. Obes. Relat. Metab. Disord., 23: 98-105.

Horswill, C.A., S.H. Park and J.N. Roemmich, 1990. Changes in the protein nutritional status of adolescent wrestlers. Med. Sci. Sports Exerc., 22: 599-604.

Hsu, T.F., A. Kusumoto and K. Abe, 2006. Polyphenol-enriched oolong tea increases fecal lipid excretion. Eur. J. Clin. Nutr., 60: 1330-1336.

Hsu, C.H., T.H. Tsa and Y.H. Kao, 2008. Effect of green tea extract on obese women: A randomized, double-blind, placebo-controlled clinical trial. Clin. Nutr., 27: 363-370.

Ito, Y., T. Ichikawa and Y. Morohoshi, 2008. Effect of tea catechins on body fat accumulation in rats fed a normal diet. Biomed. Res., 29: 27-32.

Jeszka, J., M. Czlapka-Matyasik and A. Kostrzewa-Tarnowska, 2001. Energy balance and body composition of obese children during body weight reduction programme conducted in sanatorium. Pol. J. Food Nutr. Sci., 10: 81-85.

Kao, Y.H., R.A. Hiipakka and S. Liao, 2000. Modulation of endocrine systems and food intake by green tea epigallocatechin gallate. Endocrinology, 141: 980-987.

Komatsu, T., M. Nakamori and K. Komatsu, 2003. Oolong tea increases energy metabolism in Japanese females. J. Med. Invest., 50: 170-175.

Lin, J.K. and S.Y. Lin-Shiau, 2006. Mechanisms of hypolipidemic and anti-obesity effects of tea and tea polyphenols. Mol. Nutr. Food Res., 50: 211-217.

Lukaski, H.C., 1987. Methods for the assessment of human body composition: traditional and new. Am. J. Clin. Nutr., 46: 537-556.

Maffulli, N., 1992. Making weight: a case study of two elite wrestlers. Br. J. Sports Med., 26: 107-110.

McKay, D.L. and J.B. Blumberg, 2002. The role of tea in human health: An update. J. Am. Coll. Nutr., 21: 1-13.

Murase, T., A. Nagasawa and J. Suzuki, 2002. Beneficial effects of tea catechins on diet-induced obesity: Stimulation of lipid catabolism in the liver. Int. J. Obes. Relat. Metab. Disord., 26: 1459-1464.

Nagao, T., Y. Komine and S. Soga, 2005. Ingestion of a tea rich in catechins leads to a reduction in body fat and malondialdehyde-modified LDL in men. Am. J. Clin. Nutr., 81: 122-129.

Oppliger, R.A., S.A. Steen and J.R. Scott, 2003. Weight loss practices of college wrestlers. Int. J. Sport Nutr. Exerc. Metab., 13: 29-46.

Rankin, J.W., 2002. Weight loss and gain in athletes. Curr. Sports Med. Rep., 1: 208-213.

Sato, T. and G. Miyata, 2000. The nutraceutical benefit, part I: green tea. Nutrition, 16: 315-317.

Shimotoyodome, A., S. Haramizu and M. Inaba, 2005. Exercise and green tea extract stimulate fat oxidation and prevent obesity in mice. Med. Sci. Sports Exerc., 37: 1884-1892.

Subramanian, N., P. Venkatesh and D. Ganguli, 1999. Role of polyphenol oxidase and peroxidase in the generation of black tea theaflavins. J. Agric. Food Chem., 47: 2571-2578.

Tsai, M.L., K.M. Chou and C.K. Chang, 2009. Changes of mucosal immunity and anti-oxidation activity in elite male Taiwanese Taekwondo athletes associated with intensive training and rapid weight loss. Br. J. Sports Med., 21. [Epub ahead of print].

Wagner, D.R., 1996. Body Composition Assessment and Minimal Weight Recommendations for High School Wrestlers. J. Athl. Train., 31: 262-265.

Wrisez, F. and B. Lambert, 2001. Differential long-term effects of tannic acid on adenyl cyclase activity and lipolysis in rat adipocytes. Phytomedicine, 8: 292-297.

Wu, C.H., F.H. Lu and C.S. Chang, 2003. Relationship among habitual tea consumption, percent body fat and body fat distribution. Obes. Res., 11: 1088-1095.

Yang, C.S. and J.M. Landau, 2000. Effects of tea consumption on nutrition and health. J. Nutr., 130: 2409-2412.

Yang, M., C. Wang and H. Chen, 2001. Green, oolong and black tea extracts modulate lipid metabolism in hyperlipidemia rats fed high-sucrose diet. J. Nutr. Biochem., 12: 14-20.

Yeh, C.W., W.J. Chen and C.T. Chiang, 2003. Suppression of fatty acid synthase in MCF-7 breast cancer cells by tea and tea polyphenols: A possible mechanism for their hypolipidemic effects. Pharmacogenomics J., 3: 267-276.

Zheng, G., K. Sayama and T. Okubo, 2004. Anti-obesity effects of three major components of green tea, catechins, caffeine and theanine, in mice. *In vivo*, 18: 55-62.

Zuo, Y., H. Chen and Y. Den, 2002. Simultaneous determination of catechins, caffeine and gallic acids in green, Oolong, black and pu-erh teas using HPLC with a photodiode array detector. Talanta, 57: 307-316.